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ABSTRACT

The purpose of this inservice project was to help elementary teachers overcome their reluctance to deviate from commercially prepared materials by becoming aware of and building connections between the understanding of mathematical processes through the use of concrete, representational, and symbolic manipulatives with the four arithmetic operations (addition, subtraction, multiplication, and division with whole numbers and decimal fractions). These functions were then enhanced through the infusion of computer based applications of these same arithmetic processes, to help bridge the gap in understanding between manipulative mathematics as a process, and the later use of symbolic algorithms used when solving problems. This project was accomplished through a three-phased program: task analysis, manipulative mathematics, and computer transition activities. A brief outline of each phase is given, as well as a brief discussion of the impact of the inservice program on teachers' mathematics anxiety. (IAH)

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Manipulative Mathematics with Computer Applications: An Approach to Help Practicing Elementary Teachers To Go Beyond The Textbook

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Introduction

Much research supports the premise that elementary preservice and inservice teachers suffer from mathematics anxiety (ref 1, 3, 4). Because these teachers feel uncomfortable or ambivalent toward mathematics they are likely to either avoid or lack the ability to enrich the standard curricular material supplied. In fact, these teachers often approach mathematics as a series of textbook pages to "get through" with little or no teacher input to supplement the commercially prepared materials (ref 7). This issue is confounded by the fact that these same teachers choose not to spend the same amount of instructional time on mathematics when compared with other subject areas where they feel more comfortable.

Theoretical frameworks aimed at explaining the cause of elementary teacher's high levels of anxiety toward mathematics have been authored by several researchers. Among these explanations are rationalizations centered around a teacher's poor mathematics understanding, mathematics performance or basic test anxiety, all of which seem to be related to past mathematics performance or experience. For whatever the cause elementary teachers are clearly more anxious toward mathematics than other subject areas which they teach, and as a result tend to be less willing to develop their own curricular matter to supplement or support textbook materials often labeled as redundant and boring (ref. 2).

Inservice

The purpose for this inservice project was to help teachers overcome their reluctance to deviate from commercially prepared materials by becoming aware of and building connections between the understanding of mathematical processes through the use of concrete, representational, and symbolic manipulatives with the four arithmetic operations (addition, subtraction, multiplication, division with whole numbers and decimal fractions). These functions were then enhanced through the infusion of computer based applications of these same arithmetic processes which helped to bridge the gap in understanding between manipulative mathematics as a process, and the later use of symbolic algorithms used when solving problems. This project was accomplished through a three phased program; task analysis, manipulative mathematics, and computer transition activities.

Phase One. Phase One outcomes included the completion of a detailed task analysis outlining the necessary instructional steps for the arithmetic operation of interest. Each teacher completed a task analysis of either addition, subtraction, multiplication, or division around their own particular grade level for which they were responsible. This task analysis was designed to allow teachers to become aware of the multiple bits of information which students must master in order to become effective problem solvers with the operation of interest. These bits of information were translated into student outcomes, then rephrased to represent specific developmentally appropriate teaching strategies designed to meet unambiguous intellectual requirements of students who were in need of concrete, representational, or symbolic instruction. It is important to note that these strategies were based upon student needs not teacher or administrative efficiency. Teachers often were required to plan instruction based upon the three distinct and different instructional strategies, one involving the use of concrete manipulatives, one using the computer, and one using algebraic representations.

The primary goal from the outset of phase one was to provide an awareness of the instructional map needed for each operation. This map could then be transformed into instructional strategies which would allow all students regardless of developmental level of operational understanding the opportunity to learn an arithmetic operation through adjustment of teaching strategy rather than adjustment of material or time requirements needed for mastery. In short, all students would be presented with the same material in the same time frame, only the instructional strategies would differ. The instructional strategies would be developed during phase two of the project.

Phase Two. Phase two involved a comprehensive fifteen (15) hour inservice program designed to help teachers re-learn and re-teach elementary mathematics so that it would be more aligned with the National Council of Teachers of Mathematics (NCTM) recommendations (ref. 6) for curriculum and evaluation. These recommendations call for

1) a problem solving approach,
2) appropriate language and terminology,
3) connections among and between operations, and
4) use of an approach which allows students the opportunity to use multiple mathematical strategies.

In order to help teachers follow these NCTM recommendations, a new and different approach for teaching and testing was needed. This approach required that teachers be able to

1) Assess Student level of understanding using a diagnostic tool to indicate point of student departure, and an ongoing evaluation procedure which involved curriculum based assessment using each arithmetic operation.

2) Develop and use consistent mathematical terminology which allowed students the opportunity to hear and then use "action language" describing the mathematics sentence. This action language allowed children the oppertunity to use what was given in the open number sentence to find what was not.

3) Learn a set of manipulative mathematic materials and strategies designed to help children "build" the open number sentence once the proper terminology was used. Cuisenaire Rods were used initially, followed by the use of an Abacus, Place Value Chart, Dice, Playing Cards and Calculators. Manipulatives instruction was organized as Concrete Manipulative where hands on activities involving number were developed, Representational Manipulative where hands on activities were transferred to pictorial representations, and finally Symbolic Manipulatives where abstract algorithmic applications were developed.

4) Learn about specific IBM computer hardware and software which could help ease student's transitions between each manipulative level whether Concrete, Representational, or Symbolic. The University of North Carolina - Charlotte Teacher Education Computer Laboratory was used to help these inservice teachers become familiar with, both the hardware and software of the IBM Model 30 computing system. Levels of expertise within the group ranged from no computing experience to those teachers whose primary responsibility was elementary school technology coordinator.

5) Apply a Curriculum Based Assessment (CBA) procedure to evaluate student error patterns relating to accuracy and reasonableness. This approach was based more on teacher interview and observation of students using the Concrete, Representational and Symbolic modes rather than on homework or worksheet evidence. The CBA procedure was used to help teachers become more clinical in their assessment practices as they moved away from step by step teaching and more toward student directed laboratory practices involving teacher directed clinical interview.

Phase Three. Phase three of the project consisted of using the IBM Teacher Education Computer Lab to construct Arithmetic Operation Modules. These individually developed Teacher and Student Modules were designed and developed around the Task Analysis map which was completed during Phase One of the project. Each individual inservice teacher's modules incorporated the following components:

a. Action Language

b. Appropriate Manipulative Experience at the concrete, representational, and symbolic levels

c. Computer transition activities at each manipulative level to ease the shift from lower level to higher level manipulation

d. Alternative Computational Algorithms for students who have demonstrated a history of computational difficulties

e. Checking procedures designed to measure reasonableness and computational accuracy.

Teacher modules included information for teachers which could be translated into appropriate lesson plan practices while student modules included all activities appropriate for students at each level of understanding. Modules were prepared so that student materials followed teacher materials rather than in separate packages giving inservice teachers the awareness of the flow of the operation.

These completed Teacher/Student modules were then shared with other interested group members so that each project member left with a library of Teacher and corresponding Student modules designed to enhance individualized instruction. This individualized instruction was built around a system of student action on objects rather than a series of abstract and often isolated skill instruction.

Inservice Impact on Teacher Math Anxiety

Following the intensive three week workshop described above, members of the group showed a marked decline in their unwillingness to deviate from the prescribed elementary classroom textbook. In fact, several members of the group demonstrated a readiness and genuine excitement about the possibility of replacing or enriching the textbook with their own instruction modules, clearly a novel behavior for this group of teachers. This teacher behavior was a marked departure from the behavior demonstrated at the beginning of the workshop were teachers believed they neither had the ability nor the inclination to leave the comfort of the state adopted textbook

series and accompanying ditto masters. The use of these modules is now being monitored within individual classrooms to determine not only teacher's instructional development but student progress as well.

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